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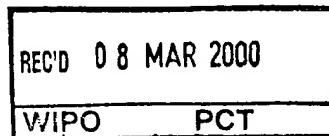
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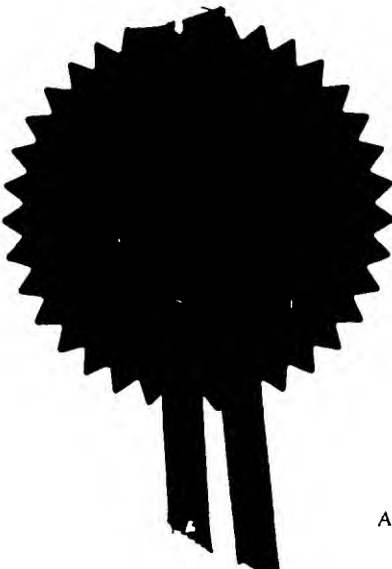
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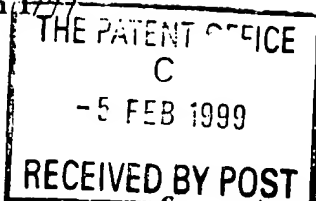
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2. Patent application number
(The Patent Office will fill in this part) **9902476.2** 05 FEB 1999

3. Full name, address and postcode of the or of each applicant (underline all surnames)
The University Court of the University of Glasgow
University Avenue
Glasgow
G12 8QQ

Patents ADP number (if you know it)

If the applicant is a corporate body, give the country/state of its incorporation United Kingdom

5646542001

4. Title of the invention
"Burner for Fabricating Aerosol
Doped Waveguides"

5. Name of your agent (if you have one) Murgitroyd & Company
"Address for service" in the United Kingdom to which all correspondence should be sent (including the postcode) 373 Scotland Street
GLASGOW
G5 8QA

Patents ADP number (if you know it) 1198013

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Description 8

Claim(s) 3

Abstract 1

Drawing(s) 3 + 3

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Priority documents -

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Statement of inventorship and right to grant of a patent (Patents Form 7/77) Two

Request for preliminary examination and search (Patents Form 9/77) One

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11.

I/We request the grant of a patent on the basis of this application.

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Murgitroyd & Company

Paclo Facitti

Date

4 February 1999

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12. Name and daytime telephone number of person to contact in the United Kingdom

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1 BURNER FOR FABRICATING AEROSOL DOPED WAVEGUIDES

2
3 FIELD OF THE INVENTION

4
5 This invention relates to a burner for fabricating
6 aerosol doped waveguides. In particular, the invention
7 relates to a modified burner which enables the in-situ
8 delivery of dopant ions in a single step process to an
9 optical waveguide during the deposition stage of
10 fabrication.

11
12 BACKGROUND OF THE INVENTION

13
14 The fabrication of silica based planar waveguides with
15 high ion content by chemical vapour deposition (CVD),
16 and in particular flame hydrolysis deposition (FHD)
17 methods, is already known in the art.

18
19 In such fabrication methods it is often desired to
20 introduce dopant ions during the deposition process.
21 The introduction of dopant ions is effected by a number
22 of known methods which suffer to a greater or lesser
23 degree from certain disadvantages. For example,
24 solution doping requires the core which makes up the
25 waveguide to be partially fused and this introduces

1 several complications.

2

3 An alternative method is to use aerosol doping. In
4 aerosol doping droplets of an aqueous solution of the
5 dopant ions are transferred to a modified FHD burner.
6 The water is evaporated to leave submicron dopant ion
7 particles. The dopant ions are then oxidised in the
8 burner flame and can be distributed during the
9 deposition stage of fabricating the waveguide.

10

11 It is known to modify conventional FHD burners to
12 incorporate an extra port for the aerosol feed. A
13 problem arises, however, when such burners are used in
14 the fabrication of heavily doped waveguides. High
15 dopant ion levels require high concentrations of the
16 aqueous dopant ion solution. During the evaporation of
17 the solvent in highly concentrated solutions, more
18 dopant ions condense around the aerosol inlet port than
19 would do with a less concentrated solution. This build
20 up of condensed ions can create blockages. The present
21 invention seeks to provide a modified burner design
22 which obviates or mitigates the problems heretofore
23 mentioned.

24

25 SUMMARY OF THE INVENTION

26

27 In accordance with the present invention there is
28 provided a burner for fabricating aerosol doped
29 waveguides, the burner including:

30 a plurality of inlet ports each connected to a
31 respective torch conduit, said torch conduit connecting
32 its respective inlet port to a gas mixing region; and
33 including a gas expansion chamber provided for at least
34 one of said inlet ports upstream of said gas mixing
35 region.

36

1 DESCRIPTION OF THE DRAWINGS

2 Embodiments of the present invention will now be
3 described by way of example only, with reference to the
4 drawings in which:

5
6 Fig. 1 is an FHD burner already known in the prior art;
7

8 Fig. 2 is a cross-section through an FHD burner of the
9 type shown in Fig. 1; and

10
11 Fig. 3 is a cross-section through a modified FHD burner
12 according to the present invention.

13
14 DETAILED DESCRIPTION OF THE INVENTION

15
16 Referring to the drawings, Fig. 1 illustrates a FHD
17 burner 1 already known in the art. The burner 1 has
18 four feed inlet ports: a halide inlet port 2, a
19 hydrogen inlet port 3, an aerosol inlet port 4, and an
20 oxygen inlet port 5. The halide inlet port 2 feeds the
21 burner 1 with halide deposition materials, for example,
22 SiCl_3 , PCl_3 , etc carried by a suitable carrier gas, for
23 example, N_2 . The inlet ports 2, 3, 4 and 5 communicate
24 with a gas mixing region 8 at the output of the burner
25 1.

26
27 The aerosol inlet port 4 supplies aerosol droplets of a
28 dopant ion solution, for example, 0.2 M aqueous ErCl_3 .
29 An atomizer 6 is used to generate the aerosol droplets
30 of the dopant ion solution. The aerosol droplets are
31 carried by a carrier gas, for example, N_2 to the aerosol
32 inlet port 4 of the burner 1. The water solvent is
33 then evaporated to leave submicron particles of the
34 dopant ions (here Er^{+3}) which are prone to condense at
35 the inlet port 4. For solution strengths above 0.2M,
36 the build up of condensed dopant ions can create a

1 blockage 7 which can clog the inlet port 4. This
2 blockage 7 occurs before the dopant ions react in the
3 gas mixing reaction zone 8, which affects the rate at
4 which the dopant ions are incorporated during
5 fabrication of a waveguide 9. The blockage 7 arises
6 due to the combination of an abrupt reduction in pipe
7 volume and the change in directionality of the carrier
8 gas flow ($\theta = 68^\circ$ from the torch axis (X in Fig. 1)).
9

10 Referring now to Fig. 2, there is shown a cross-section
11 through this type of conventional burner 1. The inlet
12 ports 2, 3, 4 and 5 are all aligned at the same angle θ
13 to the torch axis X, and transfer the feed gases (the
14 gas carrying the halide deposition materials, hydrogen,
15 the gas carrying the dopant ions, and oxygen) into
16 concentric torch conduits 10, 11, 12 and 13
17 respectively. The halide torch conduit 10, hydrogen
18 torch conduit 11, aerosol torch conduit 12, and oxygen
19 torch conduit 13 deliver the feed gases to the gas
20 mixing reaction zone 8 located in the burner nozzle 14
21 where the dopant ions are oxidised in the burner flame.
22 The oxidised dopant ions are then incorporated during
23 the deposition of the layers (not shown) which form the
24 waveguide 9 (shown in Fig. 1) a single step process.
25

26 Referring now to Fig. 3, there is shown a modified
27 burner 15 made in accordance with the invention for
28 introducing rare earth dopant ions, for example, Er^{+3} ,
29 during fabrication of a waveguide (not shown).
30

31 The burner 15 has four feed inlet ports: a halide inlet
32 port 16, a hydrogen inlet port 17, an aerosol inlet
33 port 18, and an oxygen inlet port 19. The halide inlet
34 port 16 supplies the deposition materials, for example,
35 SiCl_3 , PCl_3 , etc, which are carried by a suitable
36 carrier gas, for example, N_2 . The aerosol inlet port 18

1 supplies aerosol droplets of a dopant ion solution, for
2 example, aqueous ErCl_3 .

3
4 The halide inlet port 16, hydrogen port 17, and oxygen
5 port 19 are located in the same radial plane radiating
6 from the torch axis Y and can be all aligned at the
7 same angle θ_1 to the torch axis Y. The aerosol inlet
8 port 18 is located in a different radial plane (for
9 example, it may be displaced by 180° from the plane in
10 which the inlet ports 16, 17 and 19 are located) and is
11 positioned at a different angle θ_2 with respect to the
12 torch axis Y. The inlet ports 16, 17, 18 and 19
13 transfer the feed gases into respective concentric
14 torch conduits 20, 21, 22 and 23. The halide torch
15 conduit 20, hydrogen torch conduit 21, aerosol torch
16 conduit 22, and oxygen torch conduit 23 deliver their
17 respective feed gases to a gas mixing reaction zone 24
18 where the dopant ions, in this example Er^{+3} , are
19 oxidised in the burner flame (not shown).

20
21 The aerosol inlet port 18 has a modified structure,
22 compared to the aerosol inlet port 4 of prior art
23 burner 1. The aerosol conduit 22 is expanded at the
24 region where it connects with aerosol inlet port 18 to
25 form a gas expansion chamber 25 (here in the form of a
26 reservoir chamber). The gas expansion chamber 25
27 provides an increase in the volume of the aerosol inlet
28 port 18 and helps to maintain the concentration of
29 dopant ions and to mitigate the build up of condensed
30 dopant ions during evaporation of the aqueous dopant
31 ion solution.

32
33 The gas expansion chamber 25 enables the evaporation of
34 the dopant ion solvent to occur without the dopant ions
35 condensing at the base of the aerosol inlet port 18
36 forming a blockage at the base of the aerosol inlet

1 port 18.

2

3 A suitable volume for the gas expansion chamber lies in
4 the range of 2500 mm³ to 5000 mm³ for an aerosol feed
5 carrier gas flow rate of 3 litres/min, an aerosol inlet
6 port 18 internal diameter of 5.5 mm, and an aerosol
7 conduit 22 internal diameter of 14 mm.

8

9 In the preferred embodiment, the gas expansion chamber
10 25 is circular in radial cross-section and elliptical
11 in axial cross-section and is provided at the junction
12 of the aerosol inlet port 18 with the aerosol torch
13 conduit 22 by expanding the internal diameter of the
14 aerosol conduit 22. Alternatively, the gas expansion
15 chamber may have a different shape and/or
16 configuration. It can also be located at other points
17 where evaporation of the dopant ion solution occurs,
18 for example upstream along the aerosol inlet port 18 or
19 downstream along the aerosol conduit 22.

20

21 The prevention of a blockage occurring as the dopant
22 ions enter the aerosol conduit 22 is further assisted
23 by reducing the angle of directionality θ_2 (the angle
24 the aerosol inlet port makes with the torch axis (Y in
25 Fig. 3)). In the preferred embodiment, significant
26 reduction in the amount of condensation is provided by
27 θ_2 being substantially equal to 10°, which is in a
28 preferred range of 5° to 25°. A reduction in the
29 amount of condensation is also achieved if θ_2 is in the
30 range of 25° to 45°.

31

32 The dimensions of the aerosol conduit 22 are selected
33 to optimise the dopant process and to provide
34 directionality to the flame whilst reducing the burner
35 nozzle 26 temperature to below 1300°C. This prevents
36 devitrification of the nozzle 26 which would otherwise

1 provide unwanted contaminants.

2

3 In the preferred embodiment, with a deposition rate of
4 $1\text{ }\mu\text{m}$ of base material per traversal of the FHD burner,
5 it is possible to achieve doping levels of up to 0.72
6 wt% for an ErCl_3 solution strength of 1M with a carrier
7 gas flow rate of $2.4\text{ litre min}^{-1}$. Higher dopant levels
8 can be achieved, for example, by maintaining the rare
9 earth dopant conditions and reducing the halide flow
10 rates or by increasing the concentration of the rare
11 earth dopant solution.

12

13 Other dopant ions, for example, rare earth or heavy
14 metal ions and combinations of ions can be incorporated
15 using the burner 15 into the deposition stage.
16 Suitable solutions including rare earth and/or heavy
17 metal ions can be prepared at much higher
18 concentrations than were hitherto known in the art
19 without any accretion clogging the burner 15.

20

21 For example, a Nd doped planar silica ($\text{SiO}_2 - \text{P}_2\text{O}_5$)
22 waveguide can be fabricated using the burner 15. An
23 Nd/Al aqueous solution of 0.5M/0.4M can be used to
24 provide the waveguide with dopant ion concentrations of
25 0.25 wt% for Nd and 0.04 wt% for Al.

26

27 The modified FHD burner 15 therefore enables greater
28 control of the ion doping process during the deposition
29 stage of fabricating the waveguide. One or more ion
30 species can be introduced during the deposition stage
31 of fabricating the waveguide in a controlled manner to
32 produce waveguides with more uniform and much higher
33 dopant ion concentrations than known from the prior
34 art.

35

36 While several embodiments of the present invention have

1 been described and illustrated, it will be apparent to
2 those skilled in the art once given this disclosure
3 that various modifications, changes, improvements and
4 variations may be made without departing from the
5 spirit or scope of this invention.
6

1 Claims:

2

3 1. A burner for fabricating aerosol doped waveguides,
4 the burner including:

5 a plurality of inlet ports each connected to a
6 respective torch conduit, said torch conduit connecting
7 its respective inlet port to a gas mixing region; and
8 including a gas expansion chamber provided for at least
9 one of said inlet ports upstream of said gas mixing
10 region.

11

12 2. A burner as claimed in Claim 1, wherein the gas
13 expansion chamber is in the form of a reservoir
14 chamber.

15

16 3. A burner as claimed in either preceding claim,
17 wherein the gas expansion chamber is located at the
18 junction of an inlet port and the respective torch
19 conduit.

20

21 4. A burner as claimed in Claim 1 or 2, wherein the
22 gas expansion chamber is located upstream of the
23 junction between the inlet port and the respective
24 torch conduit.

25

26 5. A burner as claimed in Claim 1 or 2, wherein the
27 gas expansion chamber is located downstream of the
28 junction between the inlet port and the respective
29 torch conduit.

30

31 6. A burner as claimed in any preceding claim,
32 wherein said inlet ports feed oxygen, hydrogen,
33 waveguide deposition material carried by a carrier gas,
34 and aerosol droplets of a dopant ion solution carried
35 by a carrier gas to the said burner.

36

1 7. A burner as claimed in Claim 6, wherein the
2 hydrogen port is located downstream of the waveguide
3 deposition material inlet port.

4

5 8. A burner as claimed in Claim 6 or 7, wherein the
6 aerosol inlet port is located downstream of the
7 hydrogen inlet port.

8

9 9. A burner as claimed in any one of Claims 6 to 8,
10 wherein the oxygen inlet port is located downstream of
11 the aerosol inlet port.

12

13 10. A burner as claimed in any preceding claim,
14 wherein said at least one inlet port is located in a
15 radial plane with respect to a longitudinal axis of the
16 burner which differs from a radial plane containing
17 said other inlet ports.

18

19 11. A burner as claimed in Claim 10, wherein said at
20 least one inlet port is located in a plane orientated
21 at 180° to the radial plane of the other inlet ports.

22

23 12. A burner as claimed in any preceding claim,
24 wherein said at least one inlet port is orientated at a
25 first angle with respect to the burner axis, and
26 wherein the other inlet ports are orientated at a
27 second angle with respect to the burner axis, said
28 first angle being less than said second angle.

29

30 13. A burner as claimed in Claim 12, wherein said
31 first angle lies in the range 5° to 45°.

32

33 14. A burner as claimed in Claim 13, wherein said
34 first angle lies in the range 5° to 25°.

35

36

1 15. A burner as claimed in any preceding claim,
2 wherein said at least one inlet port is an aerosol
3 inlet port for providing aerosol droplets of a dopant
4 ion solution to said burner.

5

6 16. A burner substantially as described herein and
7 with reference to Fig. 3 of the accompanying drawings.

8

9

1 ABSTRACT OF THE DISCLOSURE

2

3 A burner for fabricating aerosol doped waveguides which
4 includes a plurality of inlet ports each connected to a
5 respective torch conduit; said torch conduit connecting
6 its respective inlet feed to a gas mixing region;
7 wherein a gas expansion chamber is provided between at
8 least one of said inlet ports and said gas mixing
9 region.

10

11 (Fig. 3)

12

13

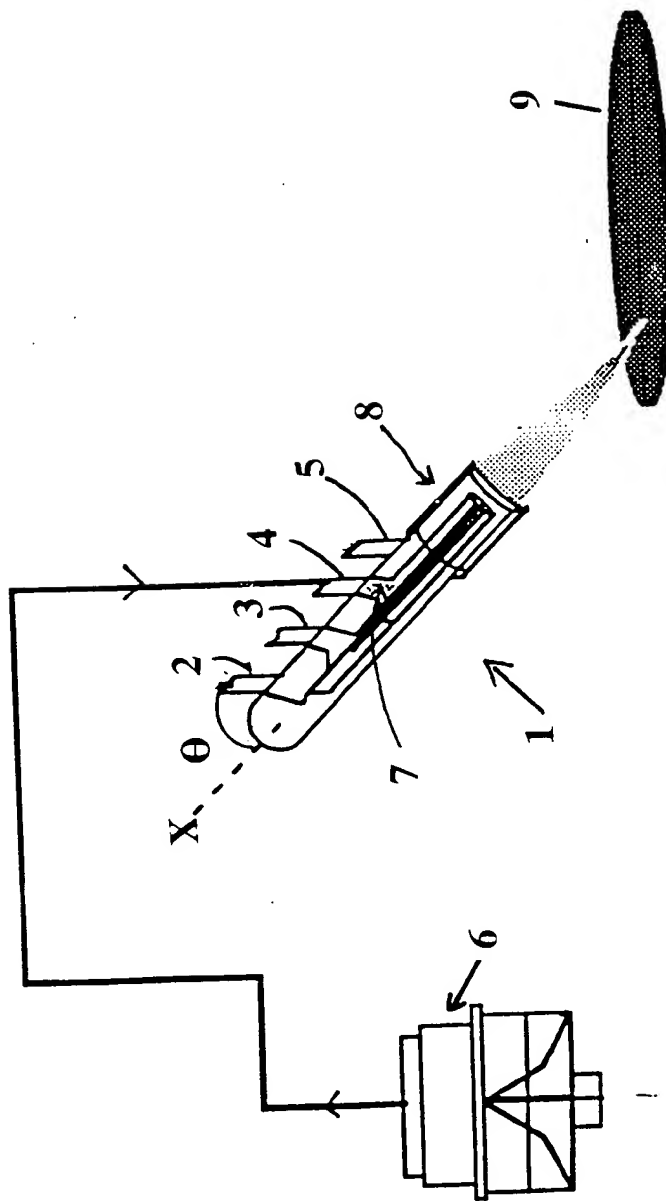


FIG. 1



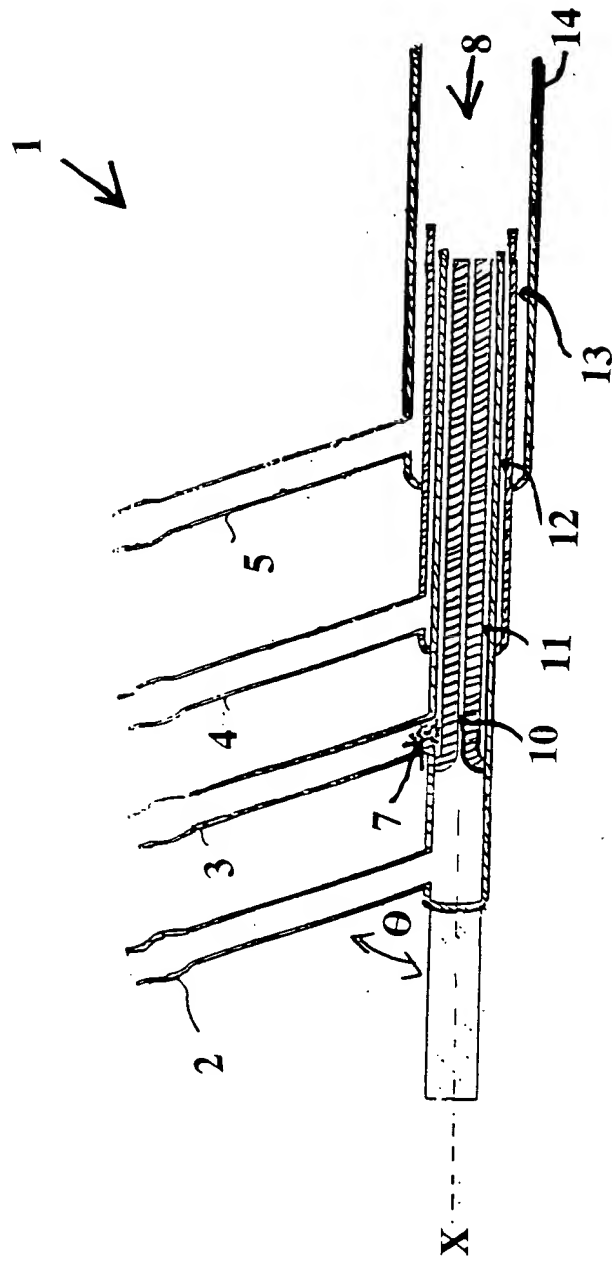


FIG. 2





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